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(GOST 3122-46)

USSR STANDARD METHOD FOR DETERMINING CETANE NUMBERS OF DIESEL FUELS

(Petroleum Industry B 27)

This standard covers the method of determining cetane numbers which characterize the spontaneous combustion of Diesel fuel in an engine. The cetane numbers in Diesel fuel indicates the spontaneous combustibility and is numerically equal to the percentage by volume of cetane - normal hexadecane - mixed with alpha-methylnaphthalene, the spontaneous combustibility of which mixture equals that of the fuel being compared to it.

The spontaneous combustibility of cetane corresponds to the cetane number 100, and that of alpha-methylnaphthalene to the cetane number 0.

1. STANDARD FUELS

1. For determining spontaneous combustibility of Diesel fuels, primary and secondary fuels are used.

2. Primary standard fuels

The hydrocarbons, cetane and alpha-methylnaphthalene possessing the following characteristics, serve as primary standard fuels:

	Cetane	Alpha-methylnaphthalene
Congelation point	Not under +16°C	Not over −20°C
Boiling range	285-290°C	238-245°C

Primary standard fuels are used to determine cetane numbers of secondary standard fuels and mixtures thereof during the recording of or checking of transition scales for secondary standard fuels and during arbitrary tests. Each portion of primary standard fuels must have a certificate designating its physico-chemical properties.

3. Secondary standard fuels

Gasoline fractions from paraffin petroleums and tractor kerosene possessing the following characteristics serve as secondary standard fuels:

Cetane number	Not under 60	Not over 30
Boiling range of group 0-90%	250-350°C	150-300°C
	degrees Centigrade	degrees Centigrade

Secondary standard fuels and their mixtures are used to determine (through transition scales) cetane numbers of Diesel fuels during operational tests.

Each portion of secondary standard fuel must also have a certificate indicating its physico-chemical properties and the cetane number derived as an arithmetical mean of the test results in at least three establishments.

II. EQUIPMENT

4. Cetane numbers of Diesel fuel are determined in standard motor CFR ASTM, reconstructed according to Diesel type. The cylinder of the engine has a separate horizontal compression chamber. The cylinder head is detachable, of variable compression, and high turbulence.

Valves are of the overhead type. The cylinder head has two apertures: One on the side for the injector; and the other on top for the combustion indicator.

The engine has one cylinder, with compression ratio ranging from 7 to 23. The compression ratio may be changed while the motor is running by shifting the small piston horizontally.

The cooling system of the engine operates by evaporation.

5. Method of fuel injection is by means of a pump and a jet.

The rise of fuel, figuring from the bottom of the fuel tank to the outflow opening of the pump must be 635±25 millimeters (25±1 inches).

6. The equipment has the following basic features:

a) One-cylinder engine with a Diesel head;

b) Apparatus for determining the instants of fuel injection and ignition (which consists of an injection indicator, Diagram 1; and an ignition indicator - Midgley's needle, Diagram 2, joined to inertialess bulbs on the rim of the crankshaft flywheel);

c) Fuel pump and jet of MOSH type (Diagram 1); the jet is connected with the injection indicator, which is a shortened Midgley's needle;

d) cyclo-phase induction motor-generator designed for starting and braking the engine;

e) Direct current generator (120 volts, 0.22 kw) for feeding current to the inertialess bulbs.

III. PREPARATION FOR TEST

7. Installation Requirements

a) Revolutions per minute: 900±9.

b) Temperature of cylinder jacket: 100±2 °C. The temperature of the cylinder jacket is held constant by boiling water (when the barometric pressure is greater than 724 mm Hg) or a solution of ethylene glycol (when the barometric pressure is less than 724 mm Hg).

A temperature fluctuation of 1 °C in the jacket of the cylinder is permitted within the range of any one experiment.

c) Machine (lubricating) oil "SU" according to OGST 1707-42, is used as lubricating oil:

Oil temperature, 52-55 °C (125-130 °F);

Oil pressure in the trunk line, 1.7-2.1 kg/sq cm (25-30 [Russian] pounds per square [Russian] inch).

d) The advance injection is 13 degrees from top dead center.

e) Injection pressure, 106±4 kg/sq cm (1500-50 [Russian] pounds per square [Russian] inch).

f) Quantity of fuel being injected, 13± 0.5 ml/min.

This quantity is defined more specifically for each fuel and the mixtures of standard fuels being tested.

g) Temperature of water cooling the jet, 38±3 °C (100±5 °F).

h) Temperature of intake air, 66±1 °C (150±2 °F).

i) The aperture of the plunger-pump has to close after the plunger has travelled from 1.9-2.3 mm (0.075-0.09 in) from the basic circle of the cam.

j) Voltage of the direct current generator during the test, 115± 5 volts.

8. Adjustment of Motor

Valve Clearance (Cold Motor):

a) In the intake valve - 0.22 mm (0.008 in)

b) In the exhaust valve - 0.25 mm (0.010 in)

9. Verifying the Accuracy of Zero Adjustment of the Gauge

The gauge is adjusted correctly, if the volume of liquid flooding the combustion chamber is 72± 0.5 ml (when the piston position is at top dead center on the compression stroke), and will fill the combustion chamber to the upper edge of the aperture for the Midgley needle. At the same time, the gauge reading should be 2 inches.

Under such an adjustment, the compression ratio (ε) can be calculated from the formula:

$$\varepsilon = \frac{18}{l} + 1, \qquad (I)$$

where: l represents the gauge length of the combustion chamber in inches.

10. Adjustment of Injection Pressure

In order to verify the injection pressure, a special pressure gauge is connected to the fuel pump and the pipe line through which the fuel passes to the jet. For the test, the jet is removed from the

cylinder and the oil ejected into the air.

The pressure gauge is set at 106 kg/sq cm (1500 psi) (Russian) and the engine started. Pressure of the pump plunger is adjusted so that the gauge and the jet inject equal quantities of fuel. Under such an adjustment, pressure at the aperture of the jet will be equal to the pressure shown by the gauge.

11. Adjustment of Injection Indicator

Upon the jet fastened in the cylinder (Diagram 1), is mounted the contact device of the injector indicator. By means of a control screw a gap of 0.8 mm is set up between the needle P of the jet and the lower spring tab. In such a position, the spring has no tension.

DIAGRAM 11

A - Small flywheel for locking the flywheel modifying the compression ratio

B - Large flywheel for changing the compression ratio

C - Micrometer for reading the length of the combustion chamber

D - Indicator of the micrometer (brace)

E - Gasket

F - Gasket nut

G - Small piston, which alters the size of the combustion chamber

H - Combustion chamber

I - Ignition indicator

K - Jet nozzle

L - Jet aperture

M - Packing ring

N - Jet

O - Screw, which regulates the tension of the lower spring tab.

P - Central Regulating Screw

R - Screw, which regulates tension of the buffer spring

T - Screw, which regulates tension of the upper spring tab.

U - Handle for on-off control of fuel injection,

The central screw P is turned down.

The screw S of the buffer spring is [redacted] turned down

The lower tab is set by means of screw A so that it lightly touches the tip of the [redacted] F. After that the screw S is [redacted] one more full turn.

By [redacted] turning screw T, the upper [redacted] spring tab is freed from tension. In this position the [redacted] contacts and must touch. If there is no contact, the upper tab [redacted] is removed and [redacted] the outer end [redacted] bent back until desired contact of the terminals is achieved. After this screw T is [redacted] backed off one more full turn [redacted].

The tolerance between the terminals is finally regulated on the operating engine by turning the central screw H until the [redacted] inertia bulb shows a bright strip of light around the flywheel. After this the central screw is [redacted] backed off two marks and fixed in this position by the [redacted] lock screw.

12. Adjustment of Ignition Indicator

The adjustment of the ignition indicator [redacted] Midgley needle (Diagram 2) [redacted] is effected as follows.

The central screw H is [redacted] backed off until it is out of contact with the upper [redacted] spring tab T.

By means of the screw A, the lower [redacted] spring tab [redacted] is adjusted so that it hardly touches the needle tip of the ignition indicator. If there is no contact, it is necessary to bend the plate slightly. Then the screw A is given one more full turn [redacted] down.

By means of screw K, tension of the upper [redacted] spring tab T is released. The terminals must now touch. If there is no contact, remove the upper tab [redacted] and turn it back slightly at its outer end until contact of terminals is achieved.

After this screw K is given [redacted] backed off one more full turn [redacted].

Screw D, which regulates the tension of the buffer spring, is turned [redacted] down tight.

By means of the central screw B, a preliminary tolerance of 0.25 millimeters is established between the terminals.

13. Starting and Stopping the Engine

After preheating the oil and the cylinder jacket to the required temperature, start the engine.

The fuel is poured into the tank and a three-way petcock regulating full inflow into the pump is installed.

The packing at the jet nozzle is checked by turning the flywheel by hand.

The electric motor is connected.

The release valve of the jet is closed.

The compression is set at the normal point of combustion.

When stopping the motor the release valve of the jet is opened, the electric motor disconnected, and the flow of fuel checked.

DIAGRAM 21

A - Screw regulating tension of the lower spring tab

B - Central regulating screw

C - Stopper Spring

D - Screw regulating tension of the buffer spring

E - Buffer Spring

F - Screw regulating tension of the upper spring tab

G - Lower spring tab

I - Upper spring tab

IV. CONDUCT OF TEST

14. The test is conducted in the following steps:

a) Make preparations for running the motor with any Diesel fuel,

b) When this is done, switch the motor to the fuel being tested and establish the degree of compression that will insure the spontaneous and uninterrupted combustion of the fuel in the engine,

c) Regulate the quantity of fuel being injected to 13±0.5 milliliters per minute by adjusting the micrometer screw,

d) Establish a gap between the terminals of the injection indicators by turning the central screw A (Diagram 1) so that a bright band of light with a truncated end appears on the rotating flywheel;

e) By turning the micrometric screw, connected with the fuel pump, the band of light on the flywheel should then be shifted so that the band is in line with the sighting tube; in this position angle of injection is 13 degrees from top dead center;

f) Decrease the compression until the engine starts "missing" which is noticeable through smoke discharges in the chamber. Then gradually increase the compression to locate that minimum degree of compression, under which it is possible to operate without interruptions in spontaneous combustion; that is, the minimum degree of compression with which the motor runs without "missing";

g) Boost the minimum degree of compression 2 units;

h) By changing the gap between the terminals of the combustion indicator, introduce a second band of light on the flywheel; the truncated end of this light band must likewise be viewed in the sighting tube; the presence of two bands of light on the same level in the tube indicates the synchronization of injection and fuel combustion; in case there is no synchronisation between the two after the compression has been raised by 2 units, increase the pressure further until the desired synchronisation is achieved;

i) After synchronising the ignitions, record the length of the combustion chamber indicated by the micrometer;

j) From standard fuels blend two mixtures differing by not more than 8 octane units. Synchronise them as indicated above, using in one case a combustion chamber longer than, and in the other a combustion chamber shorter than, the chamber length for the fuel being tested.

15. Comparison of the Fuel Being Tested with Mixtures of Primary Standard Fuels (Cetane with Alpha-methylnaphthalene).

By shifting the motor alternately from the fuel being tested to a mixture of primary standard fuels, make no less than two alternating measurements of the lengths of the combustion chamber for each fuel (length of the combustion chamber is inversely proportional to the compression ratio).

After the experiment, compute the arithmetical mean of measurements on the combustion chamber for the fuel under test and the mixtures of primary standard fuels. Also establish the cetane content in the mixture of standard fuels. This is equal by spontaneous combustibility to the fuels tested (A_x) - the cetane number, according to the formula:

$$A_x = A_1 + (A_2 - A_1)\frac{l - l_1}{l_2 - l_1} \qquad (II)$$

where A_1 - percentage of cetane in the mixture of primary standard fuels, which burn in a shorter combustion chamber as compared to the Diesel fuel under test (mixture with a small cetane number);

A_2 - percentage of cetane in the mixture of primary standard fuels, which burn in a longer combustion chamber as compared to the Diesel fuel under test (mixture with a larger cetane number);

l - arithmetical mean of measured lengths of the combustion chamber for the Diesel fuel under test;

l_1 - arithmetical mean of lengths of the combustion chamber for a mixture of primary standard fuels, which burn in a shorter combustion chamber than that for the Diesel fuel being tested;

l_2 - arithmetical mean of lengths of the combustion chamber for a mixture of primary standard fuels, which burn in a longer combustion chamber than that for the Diesel fuel being tested.

Example: The experiment has established:

Percentage of cetane content in the mixture of primary standard fuels, which burn in a shorter combustion chamber than that for fuel being tested, $A_1 = 45$ %;

Percentage of cetane content in the mixture of primary standard fuels, which burn in a longer combustion chamber than that for the fuel being tested, A_2 = 50 %;

Arithmetical mean of measured lengths of the combustion chamber for the Diesel fuel being tested, l = 1.179 inches;

Arithmetical mean of lengths of the combustion chamber for the mixture of primary standard fuels, which burn in a shorter combustion chamber than that for the Diesel fuel being tested, l_1 = 1.133 inches;

Arithmetical mean of lengths of the combustion chamber for the mixture of primary standard fuels which burn in a longer combustion chamber than that for the Diesel fuel being tested, l_2 = 1.190 inches.

From the above, the cetane number of the Diesel fuel being tested is:

$$A_x = 41 + (50 - 41)\frac{1.179 - 1.133}{1.190 - 1.133} = 47.$$

16. Comparison of the Fuel being Tested with Mixtures of Secondary Standard Fuels.

Comparison of the fuel being tested with mixtures of secondary standard fuels is conducted similarly to that for mixtures of primary standard fuels. From the comparison compute the arithmetical mean of the measurements on the combustion chamber for the fuel being tested and for the mixtures of secondary standard fuels, and determine the content of high-cetane standard fuel B_x in the mixture of secondary standard fuels. This is equivalent in spontaneous combustibility to the Diesel fuel being tested, according to the formula:

$$B_x = B_1 + (B_2 - B_1)\frac{l - l_1}{l_2 - l_1} \qquad \text{(III)}$$

where B_1 - percentage of high-cetane secondary standard fuel in the mixture of secondary standard fuels, which burn in a shorter combustion chamber than the Diesel fuel being tested;

B_2 - percentage of high-cetane secondary standard fuel in the mixture of secondary standard fuels, which burn in a longer combustion chamber than that for the Diesel fuel being tested;

l - arithmetical mean of measurements on the combustion chamber for the Diesel fuel being tested;

l_1 - arithmetical mean of the measurements on the length of the combustion chamber for the mixture of secondary standard fuels, which burn in a shorter combustion chamber than that for Diesel fuel being tested;

l_2 - arithmetical mean of the measurements of the length of the combustion chamber for the mixture of secondary standard fuels, which burn in a longer combustion chamber than that for the Diesel fuel being tested.

Example - The experiment has established: B_1 = 70 %

B_2 = 80 %

l = 1.179 inches

l_1 = 1.133 inches

l_2 = 1.190 inches

Thence - $$B_x = 70 + (80-70)\frac{1.179 - 1.133}{1.190 - 1.133} = 78\%$$

According to the meaning of B_x, the cetane number of the Diesel fuel being tested is found on a transition scale for secondary standard fuels.

17. Results of the cetane number determination are indicated in terms of integral units, fractional values from 0.1 to 0.5 inclusive being dropped, and those from 0.6 to 0.9 inclusive being accepted as whole units.

V. PERMISSIBLE DEVIATIONS FOR PARALLEL DETERMINATIONS

18. The deviations between two parallel determinations must not exceed ± 2 cetane units.

VI. CONSTRUCTION OF A TRANSITION SCALE FROM PRIMARY STANDARD FUELS TO SECONDARY STANDARD FUELS

19. For daily tests of Diesel fuels, use secondary fuels, which are standardized on the primary, instead of the primaries themselves.

20. For constructing a transition scale from primary to secondary standard fuels set up a series of volumetric mixtures of primary standard fuels (cetane and alpha-methylnaphthalene) with variations of 10 percent in cetane content.

In testing the mixtures of primary standard fuels, select for each of them two mixtures of secondary standard fuels differing by not more than 8 cetane units and synchronise ignition for one in a longer, for the other in a shorter combustion chamber as compared to that for the mixture of primary standard fuels being tested.

21. Comparison of mixtures of primary standard fuels with those of secondary standard fuels is carried out in accordance with paragraph 16 of the present standard specifications. In testing the mixture of primary standard fuels compared to the mixtures of secondary standard fuels, determine the content of high-cetane fuel (B_x) in the mixture of secondary standard fuels which is equivalent in spontaneous combustibility to the mixture of primary standard fuels being tested, according to formula III.

22. For constructing terminal points of a transition scale, always use one of the secondary standard fuels and select two mixtures of primary standard fuels, which differ by no more than 8 cetane units, and have ignition synchronized, one ~~under~~ For a longer and the other ~~under~~ For a shorter length of the combustion chamber ~~in comparison to~~ (as compared with) that for the secondary standard fuel.

Comparison of secondary standard fuels with mixtures of primaries is conducted in accordance with paragraph 15 of the present standard specifications, and the cetane number of every secondary standard fuel determined in accordance with formula II.

23. Results of computed equivalent mixtures of secondary standard fuels are set down on a graph, which is a transition scale from secondary to primary standard fuels or, more briefly, "the scale of secondary standard fuels."

When constructing a scale of secondary standard fuels on the abscissa axis, the percentage content of high-cetane secondary standard fuel in the mixture (b_x) is plotted at a rate of not less than 2 mm for every 1 %, and on the ordinate axis - the cetane number (percentage of cetane in an equivalent mixture of primary standard fuels) at a rate of not less than 5 millimeters for 1 cetane unit.

24. Secondary standard fuels taken for the construction of the scale are used in the present work until one of them is used up, or until discrepancies of over 2 cetane units occur during the periodical checks of the scale.

25. The transition scale is verified on the basis of primary standard fuels:

a) After an overhauling and clearing of the engine;

b) After adjusting the engine

Check a minimum of two points on the transition scale.

In case of discrepancies of more than ±1 cetane unit, the scale is replotted.

26. If the cetane numbers of mixtures of secondary standard fuels, figured at several points of the scale (appended to the rating document of secondary fuels) differ from the corresponding percentages of cetane content in the mixtures of primary standard fuels being tested by no more than ±1 cetane unit, the scale is acceptable.

If the variations are more than ±1 cetane unit at any point of the scale for the present determination, a new scale is made.

VII. PERIODIC VERIFICATION OF INSTALLATION

27. The valve tolerances are to be checked daily before starting the engine.

Before connecting the electric motor inspect the nozzle packing of the jet.

The nozzle is cleaned after every 10 hours of motor operation.

The plunger, controlling the degree of compression, is to be cleaned after every 20-30 hours of motor operation or more frequently as needed.

Be sure to keep the fuel line and the pump cleaned out. The fuel to be tested is to be carefully filtered.

After every 75 hours of operation, clean the valves, clean the piston rings and oil filter, and change the oil, etc.

APPENDIX

Inside Diameter of Cylinder (mm, inches)	82.5 (3.25)
Piston Stroke (mm, inches)	114.3 (4.5)
Cylinder Capacity (ml, cu in)	612 (37.33)
Turbulent Combustion Chamber (mm, inches)	
Diameter Inside	41.3 (1.625)
Adjustable length	9.5-69.8 (0.375-2.75)
Diameter of Valve Aperture (mm, inches)	30.1 (1.187)
Connecting-rod Bearing: (mm, inches)	
Diameter	57.1 (2.25)
Length	41.3 (1.625)
Front Crank (shaft) Bearing: (mm, inches)	
Diameter	57.1 (2.25)
Length	50.8 (2)
Rear Crank (shaft) Bearing: (mm, inches)	
Diameter	57.1 (2.25)
Length	108 (4.25)
Diameter of Piston Pin (mm, inches)	31.8 (1.25)
Length of Connecting-rod between centers (mm, inches)	254 (10)
Number of Piston Rings	5
Diameter of Exhaust Pipe (mm, inches)	31.8 (1.25)

Injection System

PE1)

Fuel pump BOSCH specification [redacted] 850 A302.

Jet

[redacted] BOSCH specification, DM-3083.

Fuel Line (from tank to pump) is made out of copper tubing, 9.5 millimeters (3/8 inches) in diameter.

The injecting pipe-line must have an outside diameter of 6.4 mm (.25 inch), inside diameter 3.2 millimeters (1/8 inch) and a length of 900 millimeters.

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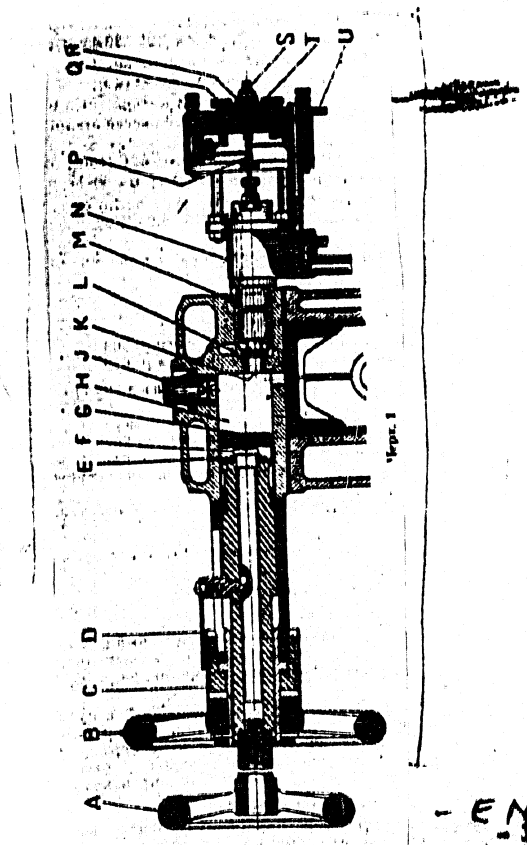
Proposed by the Department of Fuels and Oils of the All-Union Committee on Standards

Approved by the All-Union Committee on Standards, 15 November 1940



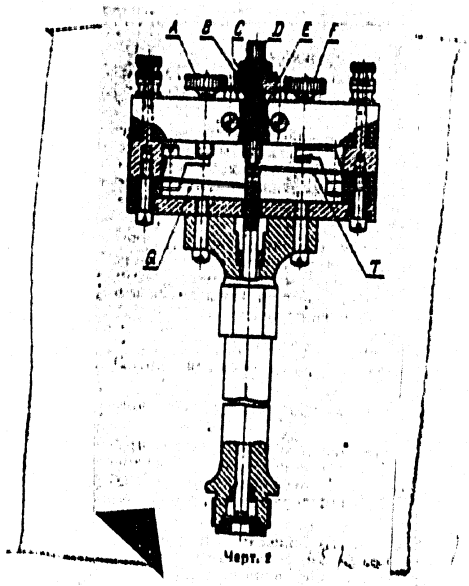


Diagram 2

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